Surface Planarization Mechanism during Dissolution in Solution Growth of 4H-SiC

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Introduction

In the solution growth of SiC, macrostep formation promotes the conversion of threading dislocations into basal plane dislocations, which are subsequently expelled from the crystal [1]. This process enables the growth of high-quality crystals. However, excessively developed macrosteps can cause solvent inclusions, which degrade crystal quality, making control of step height essential [2]. One effective method is melt-back, a process in which the crystal surface is partially dissolved. Alternating melt-back and regrowth can maintain a smooth surface for long-term stable crystal growth. From a manufacturing perspective, it is desirable to achieve sufficient surface planarization with minimal dissolution. In this study, we investigated the mechanism by which macrosteps disappeared during the melt-back process.

Experimental Procedures

First, a 1.6-inch SiC crystal was grown for three hours using a solvent of 58 at% Si–40 at% Cr–2 at% Al. Second, the surface morphology of the grown crystal was examined with a confocal laser microscope, and both the surface roughness and the cross-sectional profile of the macrosteps were measured. Third, a melt-back experiment was conducted on the same crystal. Finally, the same surface region observed before the melt-back experiment was re-examined, and the surface roughness and cross-sectional profile were measured again for comparison. In addition, the surface morphology was examined at positions where the solution flow magnitude or its direction relative to the step-flow was expected to differ, such as the central and edge regions and positions symmetric about the crystal center.

Results and Discussion

Figures 1(a) and 1(b) show microscope images of the same surface region before and after the melt-back experiment. In the as-grown surface (Fig. 1(a)), macrosteps were clearly visible, whereas after melt-back (Fig. 1(b)) they disappeared, and the surface roughness in this region decreased from 3.8 μm to 1.1 μm.

Figure 2 shows cross-sectional profiles of the same macrostep measured before and after melt-back. The profiles revealed that the upper steps dissolved faster than the lower steps, indicating that the elimination of macrosteps occurs as a result of the faster dissolution of the upper steps.

The surface morphology was compared between the crystal center and edge, where the solution flow is stronger at the edge. The edge surface was flatter than the center, suggesting that stronger solution flow promotes surface planarization. In addition, the surface morphology was compared between regions where the solution flow relative to the step-flow was parallel or anti-parallel. The surface was flatter in the anti-parallel flow region than in the parallel flow region.

Taken together, these results show that macrostep elimination during melt-back results from preferential dissolution of the upper steps and is influenced by local solution flow. These insights support the design of efficient surface planarization processes in SiC solution growth.

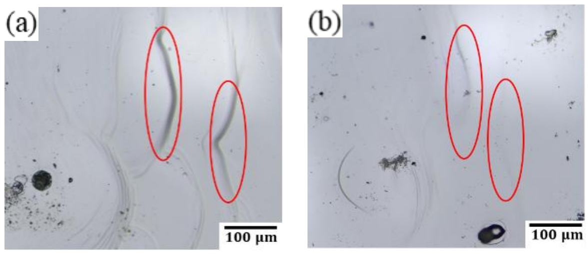

Figure 1 microscope images of the same surface region

(a) Before melt-back (b) After melt-back

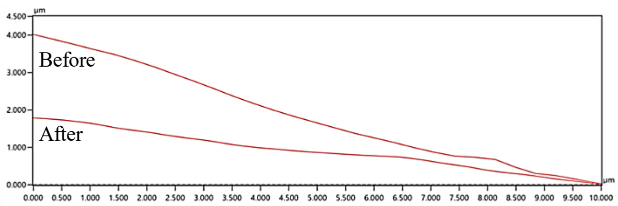

Figure 2 cross-sectional profiles of the same macrostep

before and after melt-back

References

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